5.4 Gravitational fields

This section provides knowledge and understanding of Newton's law of gravitation, planetary motion and gravitational potential and energy.
Newton's law of gravitation can be used to predict the motion of orbiting satellites, planets and even why some objects in our Solar system have very little atmosphere with the opportunity to analyse evidence and look at causal relationships (HSW1, 2, 5, 7).

Geostationary satellites have done much to improve telecommunications around the world. They are expensive; governments and industry have to make difficult decisions when building new ones. Learners have the opportunity to discuss the societal benefits of satellites and the risks they pose when accidents do occur (HSW9, 10).

5.4.1 Point and spherical masses

	Learning outcomes	Additional guidance
	Learners should be able to demonstrate and apply their knowledge and understanding of:	
(a)	gravitational fields are due to objects having mass	
(b)	modelling the mass of a spherical object as a point mass at its centre	
(c)	gravitational field lines to map gravitational fields	HSW1
(d)	gravitational field strength; $g = \frac{F}{m}$	
(e)	the concept of gravitational fields as being one of a number of forms of field giving rise to a force.	Learners will be expected to link this with section 6.2

(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

0:00:00

Lesson 1. Gravitational fields

improve lessons

Strelka, mass 12kg was the first dog in space. In her pre astronaught training she used to run around a fixed pole.

If her lead was 1.25m long and the lead supplied a tension of 17N, what speed did she run?

Extension: Explain if she was accelerating or not..

Sep 29-15:54

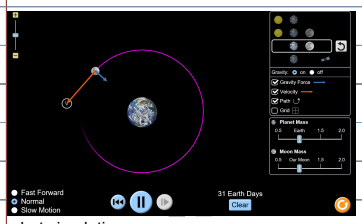
(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

0:00:00

Activity:

1. What is meant by a field?
2. What are the different types of field. → grav, electromagnetic, Strong / Weak
3. State what affects the gravitational field strength felt by an object?
   - separation between centres
   - mass of (Earth)

A field is the region in which a force operates.



phet simulation

Sep 29-15:54

(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

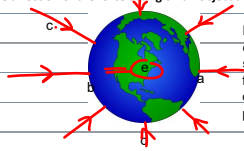
0:00:00

Gravitational Field lines

Activity:

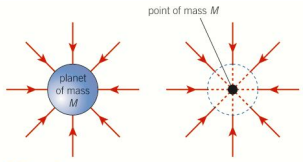
Draw lines on the diagram of the Earth to represent the Earth's gravitational field: Why have you draw the field line the way you have?

Hint: Draw the direction of the force acting on an object at that point.



Ex: consider the differences/ similarities in the field and the different positions

Make a list of 5 key point about how to draw the gravitationalfield line in this situations.



▲ Figure 4 *The separation between the field lines indicates the magnitude of the gravitational field strength. You can model a spherical mass as a point mass*

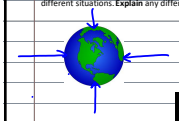
Sep 29-15:54

(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

0:00:00

Gravitational Field lines

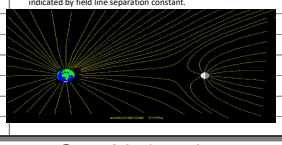
Activity: Compare and contrast the way to draw field lines for these two different situations. **Explain** any differences



Ex: Compare to the field in this region on space

- It is a radial field line
- Field lines point towards centre
- Spacing indicates strength of field
- field strength decrease with distance from the mass - indicated by field line increasing separation.
- They do not meet at the centre. The gravitational field at the centre is zero, since there is an equal amount of mass (and gravitational field) acting on you in equal and opposite directions.

- NOT radial
- perpendicula to ground
- Parallel to each other
- Spacing indicates strength of field
- field strength assumed NOT to decrease with distance from the mass - indicated by field line separation constant.



Sep 29-15:54

(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

0:00:00

Gravitational Field Strength

Weight

Key definition:

The gravitational field strength at a point is the gravitational force exerted per unit mass on a small object placed at that point

gravitational field strength, g = force / mass

g on Earth is 9.81 Nkg^{-1}

i.e. a 1 kg mass would experience a force of 9.81 N.

g is approximately equal to the acceleration of an object due to free fall (assuming no air resistance) = 9.81ms^{-2}

(They have different units and are defined differently)

Ex: Show that these two constants are homogeneous with respect to units.

Sep 29-15:54

(6) M - State what is meant by a gravitational field
(7) S - Draw gravitational field lines to represent gravitational fields
(8) C - Define gravitational fields strength and be able to calculate it.

0:00:00

Gravitational Field Strength

Ex: Gravimetry questions

Summary questions

1 Suggest why g is a vector quantity. (*1 mark*)

2 Explain why the direction of the gravitational field strength at any point around a planet is always towards the centre of the planet. (*1 mark*)

3 Calculate the gravitational field strength required to produce the following forces on a 3.00 kg mass:
a 15.0 N; b 29.4 N; c 1.62 N. (*3 marks*)

4 Describe how you can use a newtonmeter and a known mass to determine the gravitational field strength on the top of a mountain. (*2 marks*)

5 Use the defining equation for gravitational field strength to show that alternative units of g are $m\,s^{-2}$. (*3 marks*)

6 The gravitational field strength g on the surface of Mars is 3.7 $N\,kg^{-1}$. Calculate the difference in the gravitational force experienced by an astronaut of mass of 75 kg on the surface of Mars compared with the gravitational force experienced by the same astronaut on the surface of the Earth. (*2 marks*)

7 Two balls of the same diameter and masses 1.0 kg and 5.0 kg are dropped from a tower. Determine the initial acceleration of each of the balls. Explain your answers. (*2 marks*)

Sep 29-15:54